RUN-OFF-ROAD COLLISION AVOIDANCE USING IVHS COUNTERMEASURES

TASK 6 INTERIM REPORT

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Submitted by

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1.0 INTRODUCTION

The Run-Off-Road Collision Avoidance Using IVHS Countermeasures program is a five year program sponsored by the National Highway Traffic Safety Administration (NHTSA). The prime contractor for this effort is Carnegie Mellon University (CMU). Members of the project team include Battelle Memorial Institute, Calspan Corporation and the University of Iowa. The primary goal of the program is to develop practical performance specifications for roadway departure collision avoidance systems.

The program is divided into three phases. Phase I was completed in 1995, and involved the following four activities:

- Analyze the roadway departure crash population to determine frequency and circumstances associated with roadway departure crashes.
- Identify opportunities for intervention in the crash sequence and develop functional goals which a countermeasure could perform to prevent the crash.
- Test existing systems for preventing roadway departure crashes
- Develop mathematical models of potential countermeasure systems and use these models to develop preliminary performance specifications.

Phase II of the program is currently underway, and consists of two primary activities:

- Review state-of-the-art sensing, processing and driver interface technologies for their applicability to run-off-road collision prevention
- Design an advanced test bed vehicle for evaluating alternative countermeasures.

Phase III of the program will involve the following efforts:

- Construct test bed vehicle
- Conduct and document tests of alternative countermeasure systems
- Develop and publish technology independent performance specifications for roadway departure collision avoidance systems based on tests results.

This report documents the results of the second of the two Phase II activities, design of the test bed, and serves as deliverable 8 of the contract. The first two sections provide an overview of the run-off-road crash problem, and a description of the functional goals a run-of-road collision avoidance countermeasure needs to address in order to be effective. Next, it provides a preliminary plan for the countermeasure tests to be conducted in Phase III, as context for the test bed design. The remaining sections of the report document the test bed design, include the hardware and software components, and the outputs provided by the system. Also provided are a procurement plan and schedule for the construction of the test bed in Phase III.

2.0 RUN-OFF-ROAD PROBLEM OVERVIEW

Run-off-road crashes are defined to be all single vehicle crashes where the first harmful event occurs off the roadway, except for backing and pedestrian related crashes. A statistical review of the 1992 General Estimation System (GES) and Fatal Accident Reporting System (FARS) databases indicate that run-off-road crashes are the most serious of crash types within the national population. The crashes account for over 20% of all police reported crashes, and over 4 1% of all in-vehicle fatalities (15,000 / year).

Some of the most important characteristics of roadway departure crashes are the following:

- They occur most often on straight roads (76%)
- They occur most often on dry roads (62%) in good weather (73%)
- They occur most often on rural or suburban roads (75%)
- They occur almost evenly split between day and night

Unlike many of the other crash types, run-off-road crashes are caused by a wide variety of factors. Detailed analysis of 200 NASS CDS crash reports indicates that run-off-road crashes are primarily caused by the following six factors (in decreasing order of importance):

- Excessive speed (32.0%) - traveling too fast to maintain control
- Driver incapacitation (20.1%) - typically drowsiness or intoxication
- Lost directional control (16.0%) - typically due to wet or icy pavement
- Evasive maneuvers (15.7%) - driver steers off road to avoid obstacle
- Driver inattention (12.7%) - typically due to internal or external distraction
- Vehicle failure (3.6%) - typically due to tire blowout or steering system failure

3.0 COUNTERMEASURE FUNCTIONAL GOALS

The wide range of causal factors and circumstances surrounding run-off-road crashes suggest that no single functional goal will serve to prevent these crashes. Instead, careful analysis indicates that three sets of parallel functional goals are necessary (and sufficient) to address most roadway departure crashes. A block diagram depicting how these functional goals could be combined into an integrated run-off-road countermeasure system is shown in Figure 3- 1. As can be seen from the block diagram, the functions performed by the integrated countermeasure can be divided into three categories: sensing functions, processing functions and driver interface functions. Within the sensing and processing functions, there are three parallel functional sequences each leading to the issuing of an alert to the driver.

The first of these parallel functional sequences involves detecting dangerous impairment of driver state. If the driver is drowsy, intoxicated, or in some other way impaired, this sequence is intended to detect the situation and trigger a sequence of driver interface functions to prevent a crash. This functional sequence is included in the block diagram for completeness, but to avoid duplication of effort with the ongoing NHTSA driver impairment detection program, driver impairment detection is not the focus of this program.

Instead, our efforts have focused on testing systems for the other two functional sequences, which are termed “longitudinal” and “lateral” sequences. In the longitudinal sequence, the goal is to

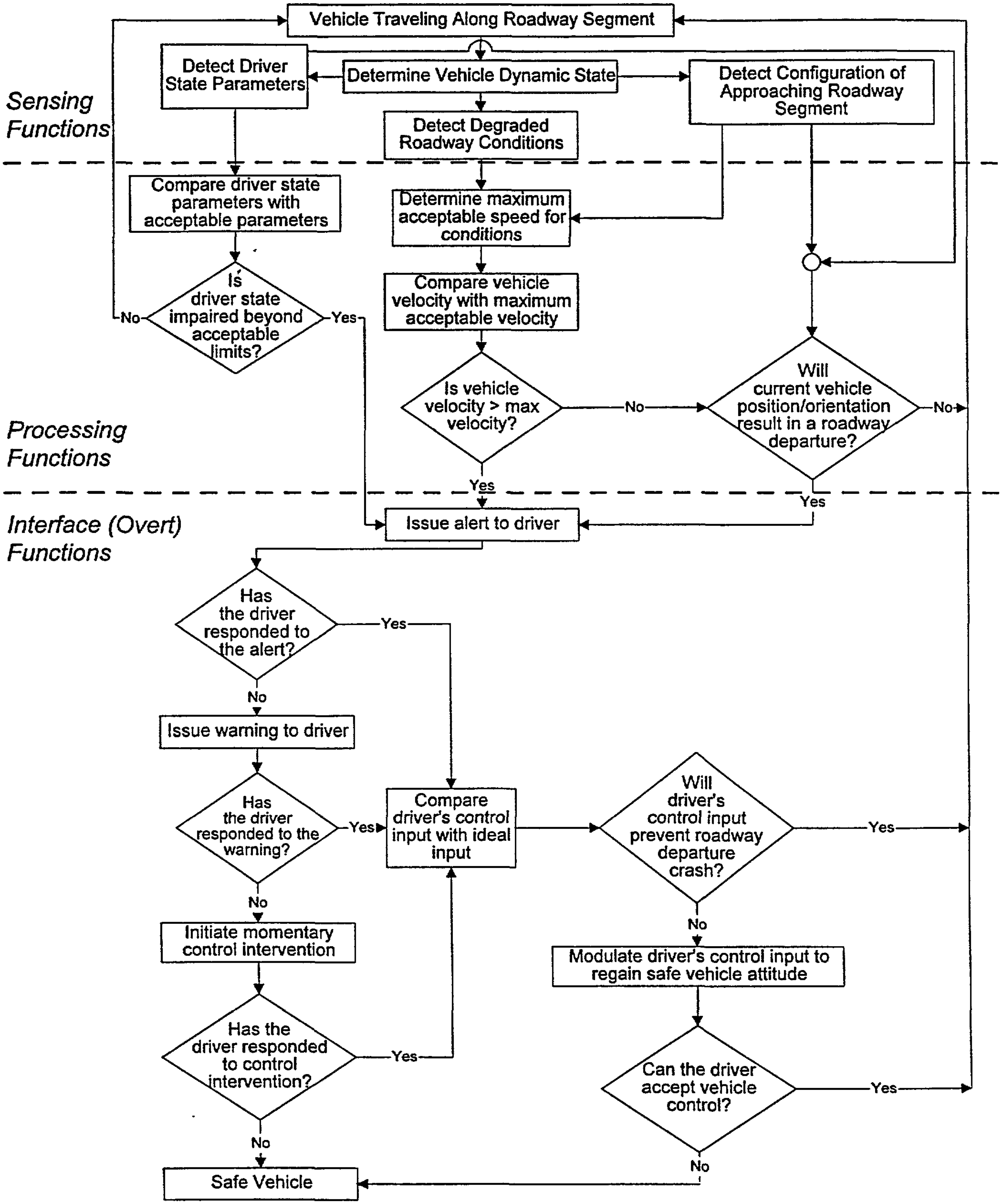


Figure 3-1: Run-Off-Road Countermeasure Functional Block Diagram

detect when the vehicle is traveling too fast for the upcoming roadway segment. The longitudinal sequence utilizes vehicle dynamic state and performance data in combination with information about the current pavement conditions and upcoming roadway geometry to determine the maximum safe speed for the vehicle. If the vehicle's current velocity exceeds the safe speed, a sequence of driver interface functions is triggered to alert the driver of the danger and avoid a crash. The longitudinal functional sequence is designed to prevent those run-off-road crashes caused by excessive speed and lost directional control.

The lateral functional sequence is designed to detect when the vehicle begins to depart the road. It utilizes data about the dynamic state of the vehicle, in combination with information about the geometry of the road ahead to determine if the vehicle's current position and orientation will likely lead to a roadway departure. If the likelihood of departure exceeds a threshold, a sequence of driver interface functions is triggered to alert the driver of the danger and avoid a crash. The lateral functional sequence is designed to prevent those run-off-road crashes caused primarily by driver inattention and driver relinquishes steering control.

It is important to note that two of the original six run-off-road crash causal factors identified in Task 1 are not addressed by these functional sequences. The first is crashes caused by evasive maneuvers in which the driver intentionally swerves to avoid an obstacle in the roadway, resulting in a roadway departure crash. It was determined that these crashes were largely being addressed by the rear-end collision countermeasures specifications program. Therefore, crashes caused by evasive maneuvers were eliminated from consideration in this program.

The second crash type not addressed by the functional sequences in the block diagram are crashes caused by vehicle failures. These crashes typically result from tire blowouts or loss of power steering due to engine failure. The analysis conducted from this program indicates that crashes from these causes are relatively rare (only 3.6% of the run-off-road crash population). In addition, countermeasures to prevent these crashes would require redesigning automotive components in a way that is beyond the scope of this program. For these reasons, crashes caused by vehicle failure have been eliminated from consideration in this program.

4.0 PRELIMINARY PHASE III TEST PLAN

As indicated in the previous section, roadway departure countermeasures can be divided into two primary classes, lateral systems to prevent drifting off the road due to driver impairment or inattention, and longitudinal systems to prevent departures due to excessive speed for the upcoming roadway. Continued investigation of both types of countermeasures is planned for Phase III, and as will be seen in subsequent sections, the test bed design reflects this dual functionality.

In order to support the develop of practical performance specifications for roadway departure, countermeasures, more must be learned about people's driving behavior under normal conditions. Therefore, our current plan for Phase III testing involves collecting data on the driving performance of naive subjects both with and without run-off-road countermeasures over a relatively extended period (l-2 weeks). We plan to allow drivers to self-select their own route, perhaps scheduling the tests when the subject is heading on a long trip, to emphasize long distance driving on unfamiliar roads, where this type of countermeasure is expected to be most useful.

If logistically possible, we plan to perform most of the data collection experiments in Phase III while the subject drives his/her own vehicle. This should avoid the problem of the driver's behavior being altered because he/she is driving an unfamiliar vehicle owned by someone else. Additional experiments will also be conducted using a specially instrumented test vehicle, with certain capabilities not possible to implement on the subject's own vehicle (e.g. haptic feedback through the steering wheel, audio system override when a warning is triggered). These additional experiments will allow us to ascertain the performance of more sophisticated countermeasure systems, as well as evaluate the hypothesis that people will drive slightly differently when in a strange vehicle.

Finally, we plan to analyze driver performance data collected by Carnegie Mellon Research Institute (CMRI) on two heavy trucks as part of the NHTSA drowsy driver program. These two trucks are equipped with identical systems to the ones we will be using for passenger vehicle data collection in Phase III. It remains to be seen whether the heavy truck data collection will include driver performance both with and without roadway departure countermeasures. At this point, CMRI is planning to only passively monitor driver performance to detect drowsiness, and not warn of impending roadway departure.

5.0 TEST BED DESIGN

While the above plans are only tentative at this point, they do provide a number of constraints which have guided the development of the test bed design. In general, the desire to perform data collection on the subject's own vehicle has lead us to the conclusion that a portable test bed will be required. The test bed will be installable in a new vehicle in under one hour, and require no modifications to the subject vehicle. The test bed will be powered off the vehicle battery, through the cigarette lighter. The test bed will be capable of supporting both lateral and longitudinal countermeasures simultaneously. It will function in two different modes, passive data collection mode for normative driver performance characterization, and warning mode for evaluation of countermeasure performance. The system will have logging facilities to record both numerical and video data of driver/vehicle performance.

The following section contains a description of the individual components of the test bed system and how they are combined into a system with the above characteristics. Further detail on the specifications of the individual hardware components can be found in section 8 titled "Component Specifications".

5.1 PROCESSING UNIT

The heart of the test bed system will be the processing unit. It will be based on a 166 MHz Pentium processor in a modified desktop PC chassis (See Figures 5-l and 5-2). It will run the QNX

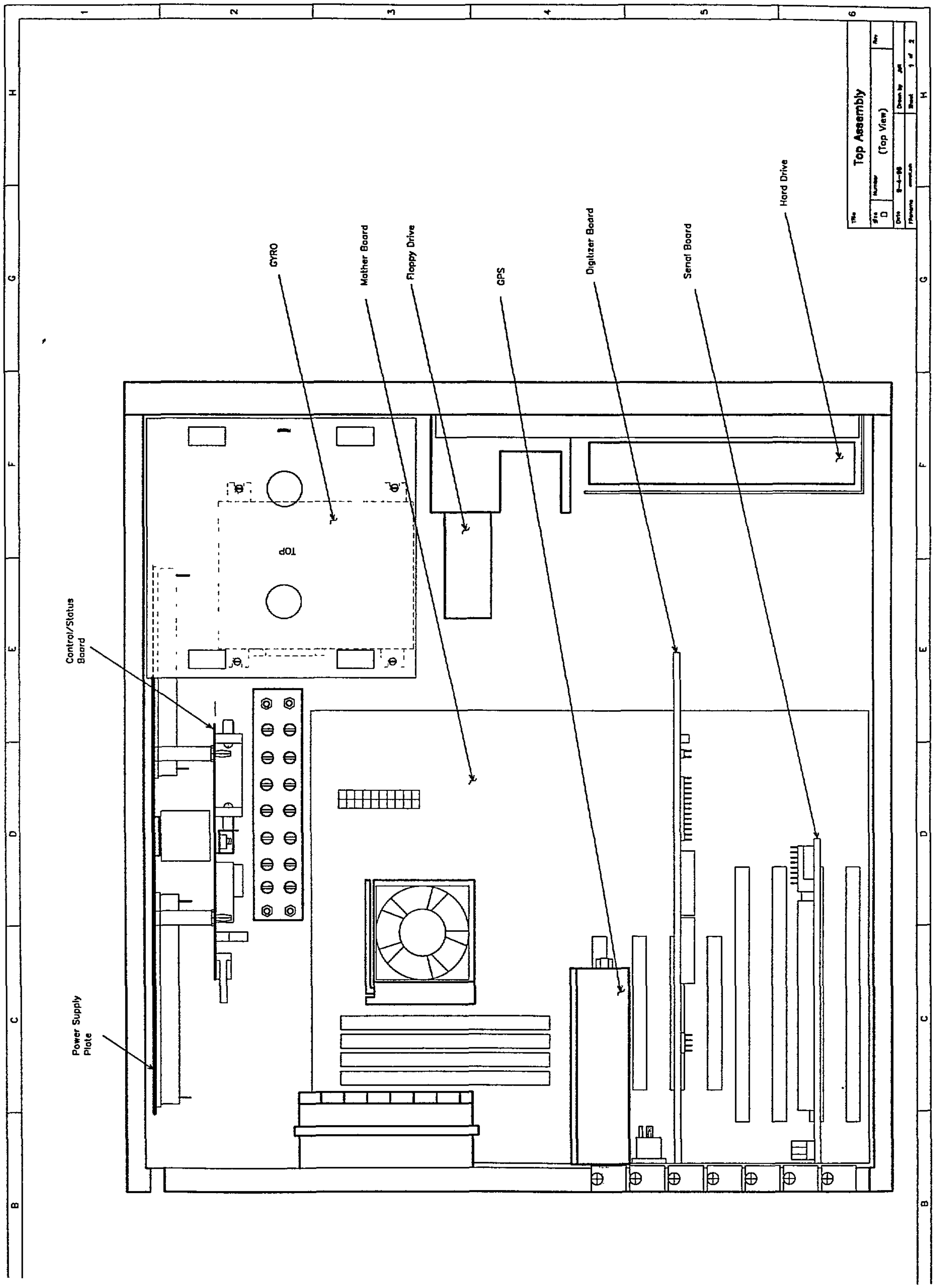


Figure 5-1: Schematic of Processing Unit: Top View

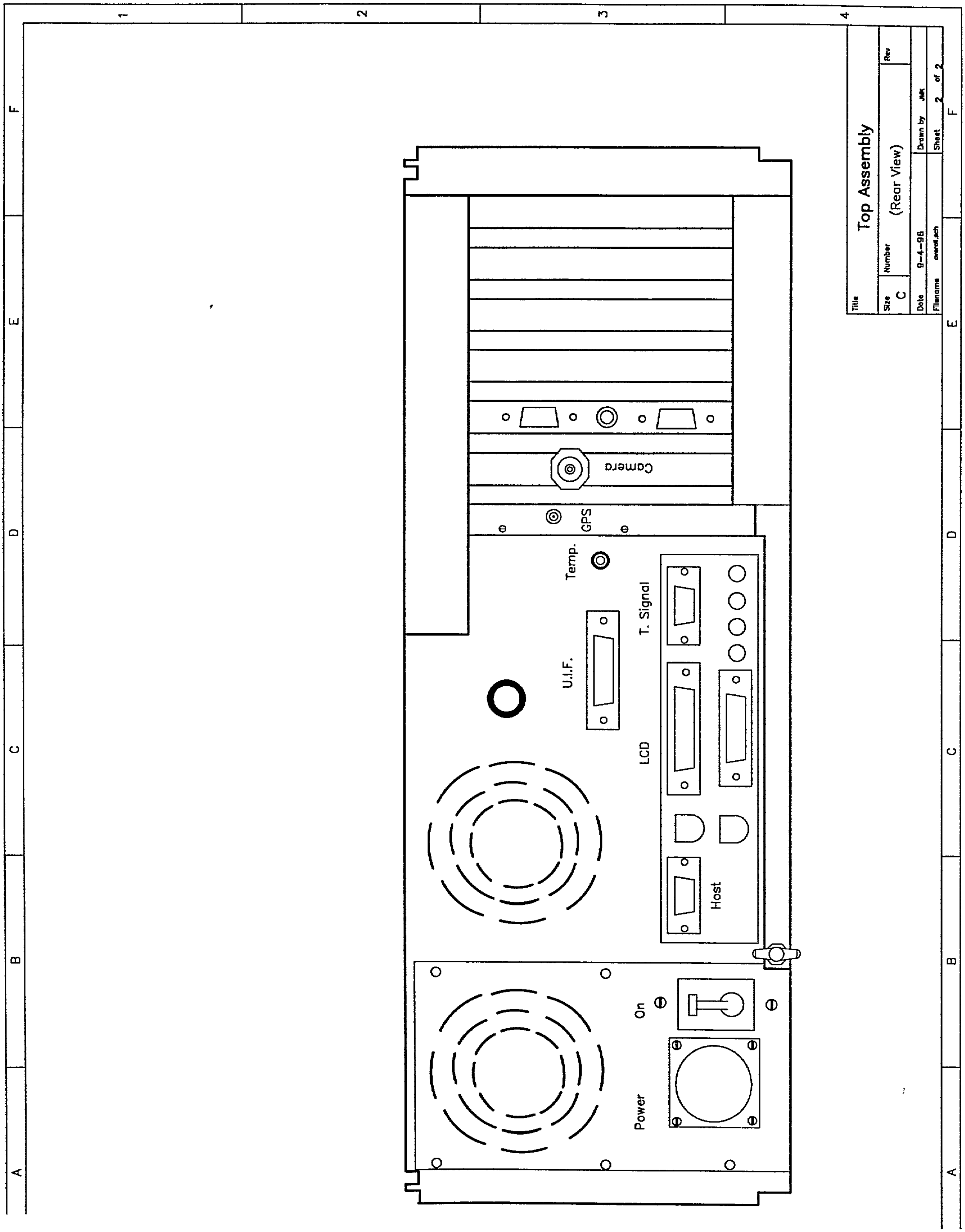


Figure 5-2: Schematic of Processing Unit: Back View

operating system, and be capable of supporting both the lateral and longitudinal countermeasures simultaneously. It will have a 1 gigabyte hard drive for data storage, which should be more than sufficient for even the longest data collection experiments.

As can be seen from the schematic, the processing unit will contain a number of additional components needed for the experiments. This includes a video digitizer card for capturing video camera images to support the lateral countermeasures. This also includes a differential GPS to provide accurate vehicle global position information in support of the longitudinal countermeasure. The processing unit also contains a gyro for measuring vehicle yaw rate, and power conditioning hardware to convert the 12V power from the vehicle battery into usable power for the whole test bed. The GPS, gyro and power conditioning equipment are discussed in more detail below.

5.2 CAMERA

The experiments conducted in Phase I of the program indicated that a forward looking lateral countermeasure has a number of advantages over a downward looking system that tracks lane markers next to the vehicle. These advantages included:

- Requiring only a single camera instead of two, one for each side of the vehicle for the downward looking system
- Requiring no support hardware (other than the camera) for environmental conditioning. The downward looking system requires auxiliary illumination to operate at night and a temperature compensated see-through enclosure to protect the camera from harsh environmental conditions.
- Capability of operating under a wider variety of conditions. The downward looking system relies exclusively on lane markings for detecting the vehicle's lateral position, making it ineffective when the lane markings are missing or severely degraded. As is described in the Task 3 report, the forward looking system does not have this limitation, and can operate based on features other than lane markings (e.g. shoulder/pavement boundaries, oil spots down the lane center, etc.) if lane markings are not available.
- Capability to estimate both instantaneous lateral position and curvature of the road ahead. This forward preview capability is missing from the downward looking system, which can only estimate the vehicle's current lateral position. Preview is crucial for detecting an impending road departure early enough to allow the driver to respond to the warning.

With these advantages in mind, the team recommends focusing on the forward looking lateral countermeasure in the Phase III testing. To support this type of countermeasure, the test bed will be equipped with a small black and white video camera, shown in actual size in Figure 5-3. This camera is small enough to be mounted behind the rearview mirror, so as not to obstruct the driver's vision. The camera will be rigidly, but temporarily mounted to the windshield of the subject vehicle using a magnetic mounting mechanism which we have already demonstrated to be effective.

The camera will be placed within the range of the windshield wipers and defrost heater, to benefit from the already available infrastructure for keeping the view of the road ahead clear. The camera

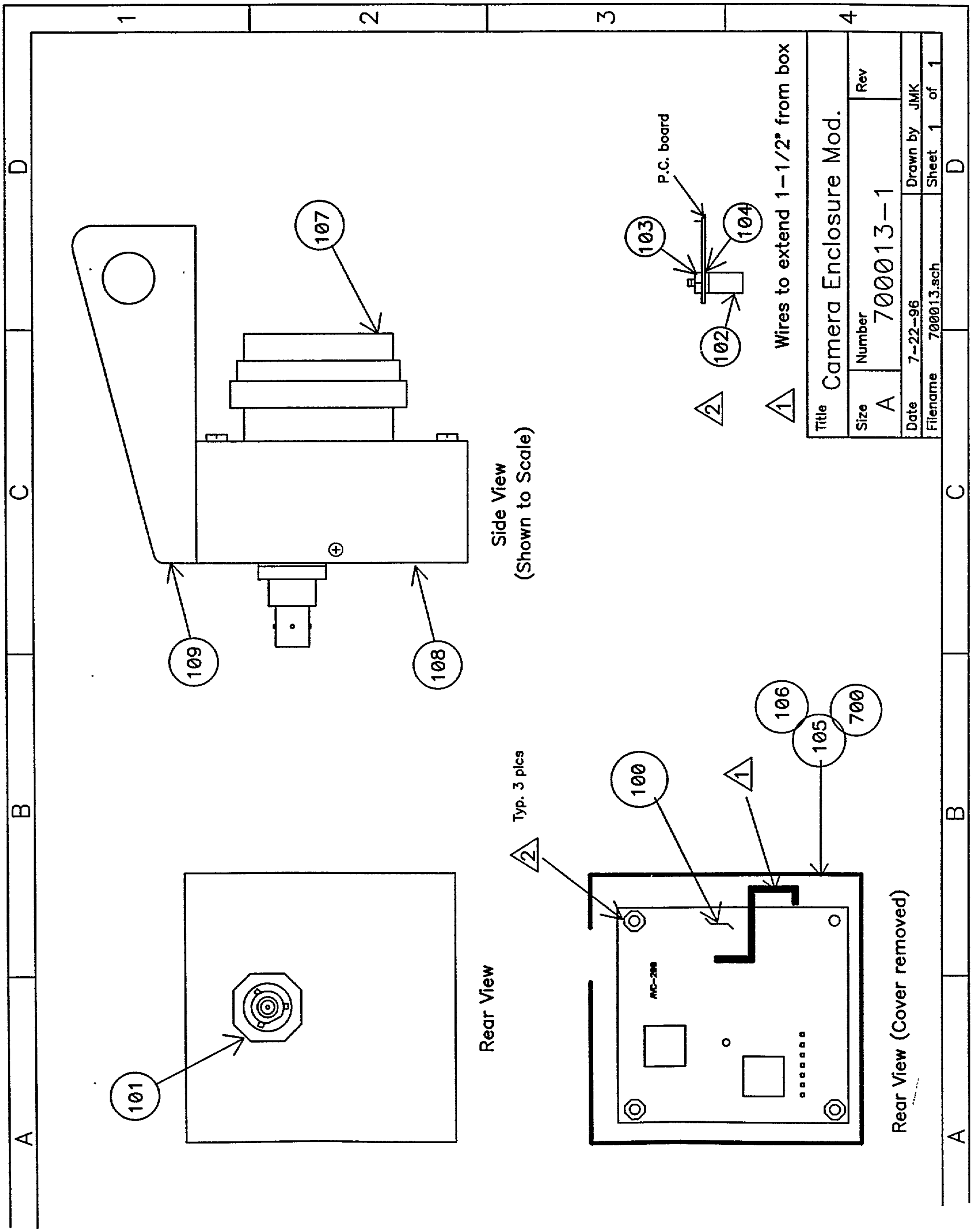


Figure 5-3: Schematic of Camera and mounting mechanism

is very sensitive to low light conditions, allowing it to operate at night using headlight illumination. It also has an electronic shutter, allowing it to handle extreme variations in external illumination, such as when entering or exiting a tunnel. For more details on the camera specification, see section 8.

The camera will be equipped with a 8mm lens, giving it a horizontal field of view of 37 degrees. Experiments during Phase I of the program demonstrated that this lens configuration allows the system to see the full width of the road a short distance ahead (approximately 8m) for accurate lateral position estimation, as well as the upcoming road segment in sufficient detail to estimate road curvature out to approximately 120m ahead of the vehicle.

5.3 DIFFERENTIAL GPS

The longitudinal countermeasure system requires an accurate estimate of the vehicle's location on the road network, in order to estimate the distance to an upcoming curve or other reduced speed section of roadway. As was demonstrated in Phase I of the program, differential GPS can provide such an estimate. We have selected an inexpensive Trimble GPS and the Accupoint FM subcarrier differential GPS unit for inclusion in the Phase III test bed. The Trimble GPS is small enough to fit inside the processing unit of the portable test bed (see Figure 5-l) and has proven in the Phase I experiments to provide reliable GPS position estimates under a wide variety of conditions.

Initial tests of the Accupoint differential unit demonstrated less than satisfactory performance in the Pittsburgh area, in that the signal was unavailable up to about 50% of the time. However tests conducted in Indiana and California demonstrated very good performance (98-99% availability). After contacting the company it was determined the problem in Pittsburgh was partly a software one in the Accupoint's algorithm for acquiring lock on the FM subcarrier radio broadcast, and partly a hardware problem with the Pittsburgh radio station broadcasting the signal. Both problems have subsequently been addressed, so system availability in the Pittsburgh area should be acceptable for Phase III testing.

Experiments in Phase I of the program demonstrated that together, the Trimble GPS and the Accupoint differential unit can provide a position estimate with an accuracy of +-5-10 meters. When combined with a detailed roadmap, either purchased from Etak or built by driving over the road previously, this information is sufficient to form a functional longitudinal countermeasure to warn of excessive speed when approaching a curve.

An additional benefit of the GPS is that it provides an accurate estimate of vehicle velocity. Using measurements of the Doppler shift of the signal from satellites being tracked, the Trimble GPS provides velocity estimates once per second with an accuracy of 0.1 m/sec. This is significantly more accurate than standard automotive speedometers, which typically have accuracies of around 0.5- 1 .0 m/sec. This method of sensing vehicle velocity has the added benefit of requiring no con-: nections to the vehicle electronics, making installation of the portable test bed much easier.

5.4 YAW RATE GYRO

A crucial component of any instrumented vehicle is a yaw rate gyro. This sensor provides data on the vehicle's rate of change of heading, and is necessary for accurately estimating the vehicle's trajectory. We have selected the Andrew "Autogyro" for inclusion in the Phase III test bed. It is a fiber optic gyro with no moving parts, which is a definite advantage in terms of reliability. It is specifically designed for automotive use, which among other things means it is small enough to fit inside the processing unit (See Figure 5- 1).

But perhaps the biggest benefit of the Andrew Autogyro is its extreme accuracy and resolution. It is able to detect changes in vehicle yaw rate as small as 0.01 degrees/second, and has a drift rate of less than 18 degrees/hour. When combined with the velocity estimate from GPS, we demonstrated in Phase I the ability to estimate vehicle trajectory with an accuracy of better than 0.6% of distance travelled. In addition, the high accuracy and fast update rate (10 Hz) of the Autogyro allows us to accurately estimate handwheel position, without attaching sensors to handwheel or steering column. Again, this is a definite advantage for ease of installation of the portable test bed.

5.5 DRIVER INTERFACE

Perhaps the most important component of any collision avoidance countermeasure is the driver interface, since it forms the link between the technology and the driver. For the portable test bed, we have strived in our design to keep the interface as simple and intuitive as possible, while maintaining the flexibility required of an experimental test bed system. Schematics of the design are shown in Figure 5-4. The driver interface consists of a knob, a dual tone buzzer, and two LEDs.

The knob on the driver interface is the sole means by which the driver can influence the countermeasure system. If the knob is in the off position, the driver will not be given warnings of road departure danger. The further the knob is turned clockwise, the more "sensitive" the warning system becomes. For the lateral countermeasure, this corresponds to increasing the threshold value for time-to-lane-crossing (TLC) or time-to-trajectory-divergence (TTD), which would result in a warning earlier in the departure sequence. For the longitudinal countermeasure, an increased sensitivity corresponds to a decrease in the speed threshold (relative to the safe speed for the upcoming road segment) above which a warning will be triggered. This is equivalent to an increase in the distance prior to a dangerous road segment (like a sharp curve) that a warning will be triggered if the driver exceeds the safe speed for the segment. The knob is read and interpreted by the processing unit, giving the system the flexibility to redefine the meaning of the knob if appropriate.

As can be seen in Figure 5-4, there is a three state LED above the knob on the driver interface. This LED is designed to relay system status information to the driver. The LED will be off if the knob is in the off position. This means the countermeasure is turned off, so it will not trigger an alarm even if the vehicle begins to depart the roadway. If the LED is red, this means the countermeasure is on, but not operating normally at this time, so warnings will not be triggered. This state will occur for example, after the ignition has been turned on to providing power to the system, but before the system has booted and begun functioning. Another example of a condition

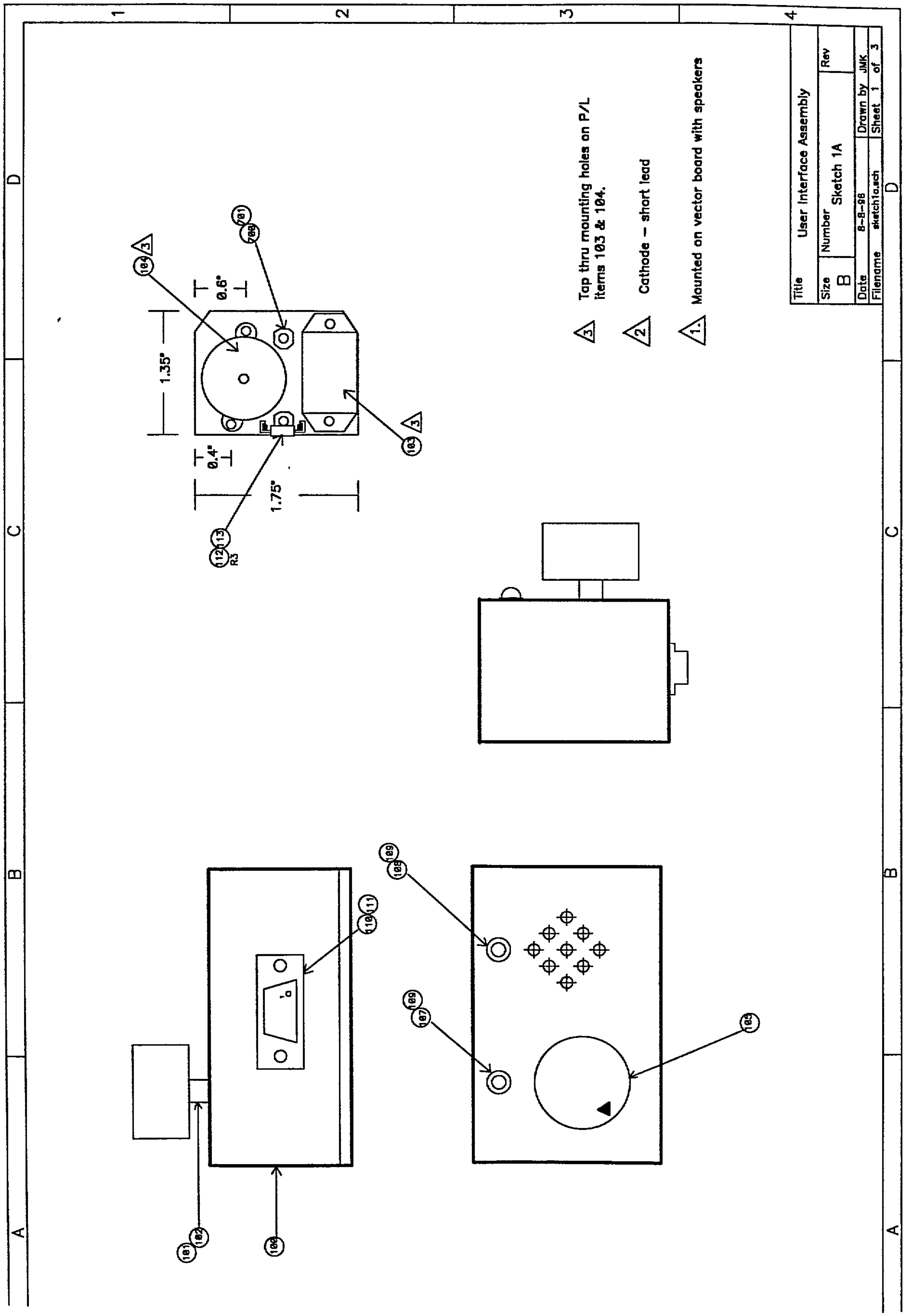


Figure 5-4: Schematic of Driver Interface

where the status LED will be red is if the system looses GPS lock for an extended period, and can therefore not accurately estimate the vehicle's position relative to upcoming curves for the longitudinal warning system. For the lateral countermeasure, a red status LED might result when the vehicle is traveling in a parking lot, and therefore there is no lane for vehicle to depart from. Finally, the status LED will be green if the system is on and operating normally. If the status LED is green, then warnings will be triggered if the system estimates that the danger of a roadway departure exceeds the threshold set with the knob. The dual tone buzzer on the driver interface is designed to provide the driver with an audible warning of an impending roadway departure. The two tones have a frequency of 500 and 2000 Hz. The capability of producing two tones is provided in order to allow for several levels of urgency or to allow the system to distinguish between lateral and longitudinal warnings. The actual manner in which these two tones should be used will be investigated further after completion of the test bed.

The LED above the dual tone buzzer is designed to provide a redundant visual indication of a lane departure condition. It will briefly flash red simultaneously with tones generated from the buzzer when the vehicle is in danger of departing the roadway.

To maintain simplicity and portability, this is the entire interface that will be available on the portable test bed, The box housing the knob, buzzer and LEDs is approximately the size of a computer mouse, and will be temporarily attached to the subject vehicle's dashboard (within reach of the driver) during Phase III testing.

Note there are several capabilities this interface does not have that may be useful or important for an eventual deployed road departure countermeasure. The system does not have a volume control, since it was judged by the team's human factors experts that an additional knob for volume would complicate the interface too much from the driver's perspective. The portable system does not have the ability to suppress the radio when an alarm is triggered, which may be necessary in a deployed system to ensure the audible warning is detectable by the driver. Finally, the portable system has no method for providing haptic feedback to the driver of roadway departure danger. The simulator experiments during Phase I of the program suggested a haptic warning, in the form of a vibrating steering wheel, may be an effective method of warning the driver of roadway departure danger, and eliciting the appropriate corrective action.

In order to support testing of these and other countermeasure extensions which are not feasible to implement on a naive subject's own vehicle for testing, the team proposes to construct a dedicated test bed vehicle. This test bed vehicle will initially be outfitted with the same equipment as the portable test bed, but will provide the capability to augment the countermeasures with additional driver interface, sensing and/or computing equipment that may be determined to be necessary for an effective roadway departure warning system. A more detailed discussion of the dedicated vehicle is provided below, in section 5.10.

5.6 EXPERIMENTER INTERFACE

Countermeasure testing and calibration requires more feedback for the experimenter than is available through the driver interface. To support these functions, the portable test bed will be equipped with a removable color LCD touchscreen display from Datalux, Inc. This LCD will support display of the VGA output from the processing unit's computer, which will allow the experimenter to edit calibration files and tune the countermeasures as necessary. The LCD will also support display of the video output from the lateral countermeasure's camera. Vehicle and countermeasure state information can be overlaid on top of the video image (as shown in Figure 5-5) making the video output of the system a rich record of countermeasure operation. This video record will be time tagged and recorded to VCR, as described in the section 5.7 on "VIDEO DATA LOGGING".

The touchscreen capability of the LCD provides "user friendly" method for the experimenter to interact with the countermeasure. One example of how the touchscreen could be used during Phase III experimentation would be to allow the experimenter (who may be riding along with the driver for certain tests) to trigger a false alarm from the countermeasure under a particular condition for each subject to measure the reaction of drivers to false alarms. This paradigm of controlled manipulation of driver/countermeasure interaction proved valuable during the simulator tests in Phase I, and we plan to provide this same capability through the touchscreen interface of the Phase III test bed. Of course not all experiments will require this capability, so the touchscreen

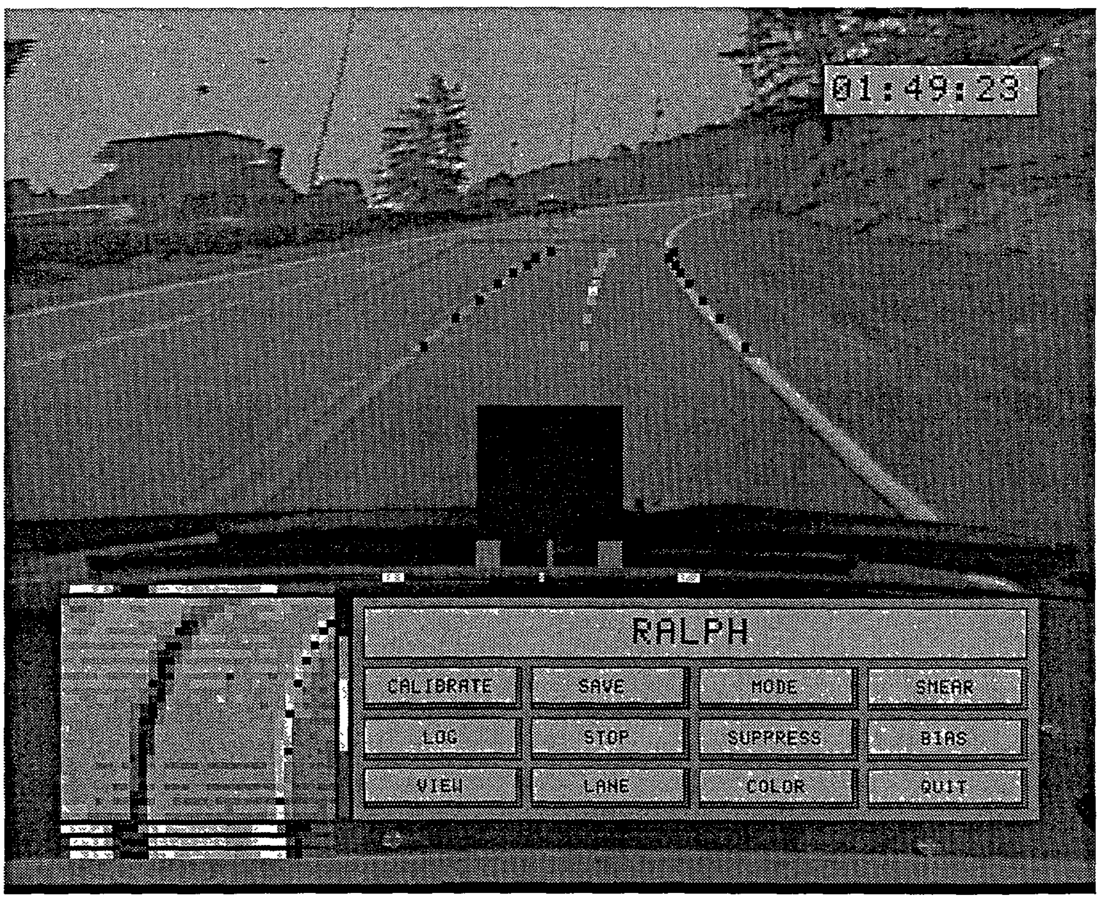


Figure 5-5: Video image from camera with graphical overlay.

is designed to be removable from the test bed when not necessary.

5.7 VIDEO DATA LOGGING

As mentioned above, a crucial function the test bed must perform is the logging of information characterizing vehicle and countermeasure performance. This logging will take two forms on the Phase III test bed: digital data logging and video data logging. Digital data logging will involve storing a time tagged record of quantitative parameters associated with the vehicle and countermeasure operation to the hard disk in the processing unit for later analysis. The form and content of digital data log is described in detail below, in section 6 titled "DIGITAL DATA LOGGING".

The video data log will be recorded using a computer controlled Panasonic SVHS VCR. The unit selected is actually the same one used on the DASCAR vehicles. The video signal recorded on the video data log will typically be the view from the lateral system's forward looking camera, although an alternative camera view, perhaps of the driver, will also be possible to record. As mentioned above, the video signal will include a graphic overlay. The information displayed on the graphic overlay will be flexible, but at this point we expect to display the following fields in real time:

- Time Tag (for registration w/ digital data log)
- Vehicle lateral offset
- Vehicle radius of curvature
- Vehicle velocity
- Upcoming road radius of curvature
- Lane width
- Time to lane crossing
- Time to lane crossing threshold
- Countermeasure confidence
- Countermeasure state (operating: yes/no/why, alarming: yes/no)

In order to reduce the size of the digital and video data logs, and simplify post-experiment analysis, both the digital and the video logging will operate in a "black box" mode, recording only selected events (and the events leading up to them). In order to implement this functionality, both the digital and video data logs will be constantly recording. At regular intervals (for example once every minute) the recorded data from the previous time interval will be erased and overwritten unless an event of interest (as defined by the experimenter) has occurred during the previous time interval. If an interesting event like a lane excursion has occurred during the interval, the data log for the previous time interval will not be erased, but will be retained for post-experiment analysis. Through careful selection of the time interval and the criteria for an interesting event, it should be possible to ensure that nearly all of the important instances, and the events leading up to them, are recorded for later analysis. The qualification of “nearly all” is due to the fact that for the video data log, it will take some small amount of time to rewind the tape over the previous uninteresting interval, during which an interesting event could occur and go unrecorded. However the advantage of a greatly reduced data log containing only important events should outweigh the slight chance of missing occasional events due to the recording procedure. Of course the system will also have the ability to continuously log video data, so as not to miss any potentially interesting events.

5.8 POWER

The electronic components of the Phase III test bed will require a consistent source of clean power to operate. It will be the job of the power subsystem to provide this power based on input from the vehicle battery, through the cigarette lighter. In Phase I of the program, we demonstrated that the cigarette lighter of all the automobiles we tested is capable to provide the approximately 120 watts of power the portable test bed will require. The power subsystem will consist of two major components: circuitry for power management, and a set of DC-to-DC converters to clean up the battery power, and provide the voltages required by the system components.

The key to the power subsystems functioning will be the power management circuitry, which will allow for “Set and Forget Operation”. The goal is to turn the system on shortly after installation, and allow the subject driver to operate the vehicle for up to several weeks without having to worry about turning the power to the system on and off, and without having to worry about having the system drain the vehicle battery.

To implement this functionality, the power management circuitry will automatically power the system on and off when appropriate. This circuitry will sense when the ignition has been turned on, and will automatically provide power to the system after a short delay to make sure the voltage from the vehicle battery has stabilized. When the vehicle is shut off, the power management circuitry will sense the drop in battery voltage, and will automatically shut the system down to avoid draining the vehicle battery. In addition, there will be a cutoff switch which will allow the driver to power down the system manually if necessary.

5.9 ADDITIONAL SENSORS

At this time, no additional sensors (other than those mentioned above) are planned for the Phase III test bed. However there are several possible additions under consideration that may prove worthwhile/necessary. They include a very accurate vehicle velocity measurement unit from a company called Datron. This sensor could be useful for detecting wheel slip in support of a friction estimation system. A second potential additional sensor is a forward looking pavement condition sensing system.

To support additional sensors, the processing unit will have addition input capabilities to receive data from other sensor sources. While these sensors may not be practical to mount on a subject's own car, the dedicated test bed vehicle (described in the next section) will provide a platform on which these additional sensors can be installed, if/when they are identified and deemed to be important.

5.10 DEDICATED TEST BED VEHICLE

While our plan is to conduct countermeasure testing in Phase III using naive subject's own vehicle whenever possible, there are a number of aspects of the Phase III effort which could benefit from having a dedicated test vehicle. First of all, if it proves to be logistically impossible to use a subject's own vehicle, then this will necessitate conducting experiments on a dedicated test vehicle. From a technical perspective, there are a number of advantages to a special test vehicle. As mentioned earlier, this will allow for installation of special sensing and/or driver interface equipment, something that may be impossible to do on a subject's own vehicle. Conducting experiments on a single vehicle also eliminates the potentially confounding effects of having subjects each driving a different vehicle (with different sizes, dynamic characteristics, etc.) during the Phase III data collection experiments.

Additionally, the countermeasures under investigation in this program are still in the development stage, and will probably require tuning/modifications based on what is learned from initial experiments with naive subjects. Have a complete dedicated hardware platform (including vehicle and countermeasure system) will facilitate this tuning process.

Finally, there may be important insights into driver behavior to be gained through testing subjects on both their own vehicle and on an unfamiliar test vehicle. An open question in the area of human factors for driving is how much driver behavior is influenced by the vehicle. It may be that because the vehicle is owned by someone else, a person will drive more carefully than normal, leading to a smaller average lane deviation. Conversely, it could be argued that because the vehicle is unfamiliar, the driver's control is likely to be less precise than when driving his/her own vehicle. The answer to this question could shed light on the validity of data collection experiments conducted solely on special test vehicles.

For these reasons, the team plans to build a dedicated test bed vehicle in addition to the portable test bed described above. The vehicle will initially have the same suite of hardware as the portable test bed, but will be outfitted with specialized sensors and/or driver interface components as they become necessary. Because the core of the dedicated test vehicle will be the portable test bed system, this will provide a second copy of the portable test bed for use during tests on subject's own vehicle. This second copy will serve as a backup in case of hardware problems with the first system, or it will allow us to run extended data collection experiments on two subjects at a time, doubling our rate of data collection.

Our plan is to acquire an APV mini-van (i.e. Pontiac Transport or Chevrolet Lumina) to serve as' the dedicated test bed vehicle. This particular vehicle has several advantages. First, we are familiar with its hardware, and in fact already have the designs for mounting the various hardware components, including a steering actuator to serve as a haptic display, from our work on Navlab 5 (a Pontiac Transport) during Phase I[1]. Second, because of its relatively small size, it drives very much like a sedan, and should therefore not severely disrupt subject's driving behavior. But at the same time, it has substantial room, particularly if the rearmost seats are removed, for additional equipment that may be necessary. Finally, even with the rear seats removed there is still enough seating for up to 5 people comfortably. In the past this has proven to be very advantageous for conducting demonstrations, like the recent AVCS committee meeting demo at the TRC in Ohio. The final dedicated test bed vehicle will look very much like Navlab 5 (shown in Figure 5-6)

Figure 5-6: Navlab 5 Test Vehicle

without the decals.

6.0 DIGITAL DATA LOGGING

A huge stream of potential useful data regarding driver and countermeasure performance will be continuously generated by the countermeasure systems and stored to hard disk in digital format. This section provides an outline of the data that we currently envision being available from the countermeasures, at an update rate of approximately 20 Hz. Note that not all of this data will be useful for every experiment to be conducted. The 'black box" mode of data recording described earlier in the section on video data logging, will also be employed during digital data logging to reduce the amount of data stored to the processing units hard disk. Additionally, any subset of the following 60 byte output message can be selectively logged, greatly reducing the size of the data files.

1. Note, the Navlab 5 test vehicle used during Phase I will be used by another project (the Automated Highway System) during Phase III of this program, aud so will not be available.

:

Table 1: Test Bed System Output

Byte	Parameter	Description	Range/Value	LSB	Bytes
1	Sync1	Sync Byte	0x5A	NA	1
2	Sync2	Sync Byte	0xA5	NA	1
3 - 4	System Status	Old data (0) / New data (1)	0x0001	NA	2
		Lane Departure Enabled	0x0002		
		Using Narrow(0) or Wide(1) View	0x0004		
		Auto View Shifting On/Off	0x0008		
		Auto Lane Width Adj. On/Off	0x0010		
		Strong Left Boundary	0x0020		
		Strong Right Boundary	0x0040		
		Ignoring Left	0x0080		
		Ignoring Right	0x0100		
		Left Turn Signal On/Off	0x0200		
		Right Turn Signal On/Off	0x0400		
		Reporting On/Off	0x0800		
		Disk Logging On/Off	0x1000		
		Using Long (0) or Short (1) Output Message Format	0x2000		
		Auto Resetting On/Off	0x4000		
		Spare	0x8000		
5	Event	No Event	0	NA	1
		Lane Departure Alarm Triggered	1		
		Reset Occurred	2		
		User Preferences Saved	3		
		Default Preferences Loaded	4		
		Log File Uploaded (to Floppy)	5		
		User Button1 Pressed	6		
		User Button2 Pressed	7		
		User Button3 Pressed	8		
		User Button4 Pressed	9		

Table 1: Test Bed System Output

		TBD	10 to 255		
6 - 9	Time	Time of Output Message (Relative to Midnight GMT)	0 to 860,400 sec	1 msec	4
10	Confidence	System Confidence in Estimates	0 to 1	0.01	1
11 - 12	Displacement	Vehicle Lateral Displacement (Negative = Left of Center)	-10 to 10m	0.01 m	2
13 - 14	Average Road Curvature	Road Curvature Estimate (Negative = Left Curve)	-0.1 to 0.1l/m	0.00001 l/m	2
15	Bottom Lane Center	Lane Center Position at Bottom of View Window	-6.25 to 6.25 m	0.05 m	1
16	l/4 Lane Center	Lane Center Position l/4 Way Up View Window	-6.25 to 6.25 m	0.05 m	1
17	l/2 Lane Center	Lane Center Position 1/2 Way Up View Window	-6.25 to 6.25 m	0.05 m	1
18	3/4 Lane Center	Lane Center Position 3/4 Way Up View Window	-6.25 to 6.25 m	0.05 m	1
19	9/10 Lane Center	Lane Center Position 9/10 Way Up View Window	-6.25 to 6.25 m	0.05 m	1
20 - 21	Vehicle Curvature	Current Vehicle Turn Curvature	-0.1 to 0.1 l/m	0.00001 1/m	2
22	Velocity	Vehicle Velocity	0 to 127mph	0.5 mph.	1
23 - 24	Yaw Rate	Vehicle Heading Rate	-30 to 30 deg/sec	0.01deg/sc	2
25 - 28	X	Vehicle Relative X Position	-20,000,000 to 20,000,000 m	0.01 m	4
29 - 32	Y	Vehicle Relative Y Position	-20,000,000 to 20,000,000 m	0.01 m	4
33-34	Heading	Vehicle Global Heading	-180 to 180deg	0.01 deg	2
35 - 38	Latitude	Global Vehicle Latitude	0 to 90 deg	0.000001 deg	4
39-42	Longitude	Global Vehicle Longitude	-180 to 180 deg	0.000001 deg	4
43	Satellites	Number of Satellites GPS Currently Tracking	0 to 6 Satellites	1 Satellite	1
44	Proximal View Distance	Distance to the Nearest Edge of the Current View Window	0 to 200m	l m	1
45	Distal View Distance	Distance to the Farthest Edge of the Current View Window	0 to 200 m	l m	1
46	Lane Width	Current Lane Width	2.5 to 5 m	0.04 m	1

Table 1: Test Bed System Output

47	Logging Frequency	Current Target Reporting Frequency	0 to 12.5 sec	0.05 sec	1
48	Warning Threshold	Current Lane Departure Warning Threshold	-1 to 2 sec	0.05 sec	1
49	Temperature	Ambient Temperature Inside Processing Unit	-20 to 60 Deg C	0.33 Deg C	1
50	Obstruction Distance	Distance to First Visual Obstruction	0 to 200m	1m	1
51	Obstruction Lanes	Bits 0, 1 and 2 Represent Right, Center and Left Lanes Obstructed	0-7	NA	1
52	Obstruction Velocity	Relative velocity of visual obstruction (negative means we are closing on obstruction)	-63 to 63 mph	0.5 mph	1
53	Reset Offset	Reset Offset	-2 to 2 m	0.02 m	1
54	Version	Version Number of System	0.0 to 25.0	0.1	1
55	User Event	User Supplied Byte Inserted into Report	0-255	1	1
56-59	Spare				
60	Checksum	Lower 8 bits of sum of preceding message bytes (including 2 header bytes)	O-255	1	1

Note: The long message format contains each of the fields listed in Table 1. The short message format contains a subset of the fields in Table 1, stored in the order listed in Table 1. The actual subset of fields included in the short message format can be tailored to fit the needs of the experiment being conducted.

7.0 PROCUREMENT PLAN

This section describes the details of the procurement plan for the Phase III test bed equipment. Almost all of the hardware for one of the portable test bed systems will be provided free of charge to the program by AssistWare Technology, a CMU spinoff company (headed by Dean Pomerleau). In particular, AssistWare will provide the processing unit, the camera, the GPS, the yaw rate gyro, the driver interface, the experimenter interface, and the power subsystem. The remainder of the components for the first portable test bed system (including the differential unit for the GPS, the VCR and any additional sensors) as well as the second complete portable test bed system will need to be purchased. Additionally, the mini-van which serves as the dedicated test bed vehicle' will need to be purchased. The exact cost of the vehicle plus portable test bed equipment is not known at this time, but will certainly be within the Phase III equipment budget of $104,000.

We expect the acquisition and/or construction of the test bed systems (including the dedicated test vehicle) will be completed approximately 6 months after the team receives NHTSA approval to proceed with Phase III. The following is the schedule for test bed construction and initial testing.

Table 2: Test Bed Build Schedule by Months after NHTSA Approval

	TASK/MILESTONE	0	1	2	3	4	5	6
1	Receive NHTSA Phase III Go Ahead	■						
2	Receive First Portable Test Bed System		■					
3	Procure Dedicated Test Vehicle		■					
4	Install Portable Test Bed System on Dedicated Test Vehicle			■				
5	Test/Debug Portable Test Bed Svstem on Dedicated Vehicle			■	■	■	■	■
6	Procure Second Portable Test Bed System				■			
7	Verify Installation and Functioning of Second System on Vehicles Other than the Dedicated Test Vehicle					■	■	■

8.0 COMPONENT SPECIFICATIONS

The following section contains detailed technical specifications for the major components of the portable test bed system, including processing unit, camera, GPS, gyro, LCD, VCR and power conditioning equipment.

Toll Free: 1-800-209-9686
900 East Karcher Rd. Nampa Idaho 83837
208-893-3434 [FAX) 208-893-3424
(PO FAX) 208-893-8992

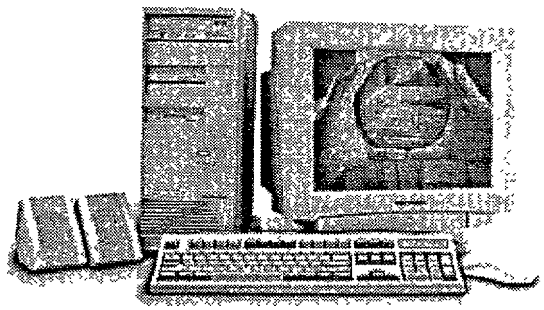
MICRON*ELECTRONICS

[Back to Home I Products]

- - -

[Price Sheets List]

Millennia P166 (A) $1,999



- 166MHz Intel Pentium Processor
- 512K Pipeline Burst SRAM cache
- 16MB EDO RAM (upgradeable to 128 MB)
- 3 ISA, 3PC1, 1 ISA/PC1 Slot shared
- Phoenix Plug-n-Play Flash BIOS (Upgradeable)
- Intel 82430HX PCI chipset
- 1.44 MB 3.5" floppy disk drive
- 1.2MB/S 8X Eight Speed ATAPI IDE CD ROM drive
- 32-bit local bus Enhanced IDE hard drive controller
- 1.2GB PCI Enhanced IDE hard disk drive w/mode 4
- Diamond Stealth 3D 2000 Video Card w/4MB EDO & MPEG
- 15" Micron 15FGx .28 digital SVGA non-interlaced color monitor
- Creative Labs Sound Blaster 16 sound on board
- Advent AVO07 computer speakers
- 1 parallel, 2 serial ports
- MiniTower chassis with "Tool Free" design
- 104 - key enhanced ps/2 keyboard
- MS Mouse with Mouse Manager (ps/2)
- MS Windows 95 & MS Plus! Pre-loaded on CD-ROM
- MS Works 95 on CD-ROM
- FCC class B, UL, CUL, & CE certified
- Energy Saving Features
- 5 Year Limited Warranty on microprocessor and main memory
- 3 Year Limited system Warranty

Processor Options

- 100MHz Intel Pentium processor subtract $300
- 133MHz Intel Pentium processor subtract $200
- 150MHz Intel Pentium processor subtract $100
- 200MHz Intel Pentium processor add $100

Software Options

- Quicken Financial Pak includes: Quicken Deluxe 5.0; Quicken Financial Planner; Quicken Parent's Guide to Money; Quicken Family Lawyer add $69
- MS DOS 6.22, Windows for workgroups 3.11 same price as Win 95
- MS Windows NT 3.51 workstation add $99

Hard Drive Options

- 2.1GB Enhanced IDE hard drive add $100
- 3.1GB Enhanced IDE hard drive add $200
- 1.0GB Fast SCSI-2* hard drive add $200
- 2.0GB Fast SCSI-2* hard drive add $600
- 4.0GB Fast SCSI-2* hard drive** add $1,000 *Includes a 32-bit PC1 Ultra SCSI Fast-20 Controller
- 9.0GB Fast SCSI-2** hard drive add $2,100 **Requires a Tower case

Video Options

- 14" Micron 14FG SVGA color monitor subtract $ 100
- 17" Micron 17FGx SVGA color monitor add $250
- 17" Hitachi Superscan 17 11 color monitor add $400
- 21" Hitachi Superscan CM801 color monitor add $ 1,300
- Diamond Stealth 64 Video VRAM with 2MB add $150
- Diamond Stealth 64 Video VRAM with 4MB add $300
- #9 Imagine 128 Series II 4MB VRAM 3D Video Card add $500
- #9 Imagine 128 Series I8MB VRAM Video Card add $750
- No Monitor subtract $250

Other Options

- Adaptec AHA-2940U SCSI Host Adapter add $100 (Upgrade from Standard PC1 Ultra SCSI Fast-20 Controller)
- DRAM Upgrades ($15 Per MB)
- Tower Case add $50
- Desktop Case Same Price as the MiniTower
- US Robotics Sportster V.34 28.8 Int. Fax/Modem add $139
- 28.8 Internal Fax Modem w/Speakerphone, and Voice Mail add $159
- 115ms 8X Eight Speed 1.2MB/S SCSI-2 CD-ROM add $200 (Does Not include interface kit)
- 115ms 8X Eight Speed 1.2MB/S SCSI-2 CD-ROM add $250(Includes interface kit)
- Microsoft Natural Keyboard add $49
- Microsoft Sidewinder Pro 3D Joystick add $59
- Sound Blaster 32 wavetable 3D sound w/Ok RAM add $59
- Sound Blaster 32 wavetable 3D sound w/2MB RAM add $99
- Advent AV270 powered partners stereo speakers add $99
- Advent AV370 powered partners w/sub woofer add $199
- Iomega Ditto 800 (400/800mg) Tape B/U add $149
- Iomega Ditto 3200 (1.6g/3.2g) Tape B/U add $ 199
- Iomega IDE ZIP Drive w/l00MB Removable Cartridge add $99
- Iomega SCSI JAZ drive w/l .OGB removeable cartridge (does not include interface) add $399

SUPERCIRCUITS

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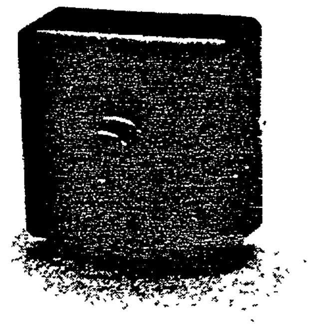


PC-18 SERIES

PLEASE READ BEFORE OPERATING

Thank you for choosing the Super-circuits PC- 18 series Superminiature Video Camera. You are now owner of one of the world's smallest video cameras, a miracle of VSLI and CCD technology.

Operation of the camera is quite simple. First, a good quality coaxial cable should be used to carry the video signal, connected to the RCA type connector. If your camera is equipped with the audio option, one RCA plug is video and the other is audio. The audio output is "line level." Power lead is a coaxial power plug, configured "tip positive." This is important...please note the diagram on the reverse side of this sheet. Warranty coverage does not extend to cover broken leads caused by excessive flexation. We suggest you mount the camera in an enclosure to avoid excessive strain and flexation of the leads. Touching power positive to video can be fatal to the camera, so be sure leads are properly insulated at termination points.

Be sure to observe correct polarity when powering up the unit. Incorrect polarity is the number one cause of failure, so please be careful in this area. The power requirements are 9-15 volts DC at 100 milliamps. Some 12 volt adapters that have been overloaded actually put out around 20 volts, so if you have any doubts about your power supply, please check it under load with a voltmeter.

Monitors and other devices emit magnetic radiation and other types of potential interference. We suggest you immediately mount the PC-18 in a protective enclosure to guard against magnetic and RF field interference, static shock and physical damage. When operating the PC- I8 in a temporary mode, please hold it a distance away from the monitor and take measures to guard against static shock and other damage.

Thank you again for choosing the Supercircuits PC-18. For technical assistance, please call us at (512) 335-9777.

Please note: This camera must be connected to a "video" input. It will not operate when connected to a cable or RF input.

PLEASE DOUBLE CHECK POLARITY AND CONNECTIONS BEFORE OPERATING.

PC-1 8XS/XP/XC Specifications

Image Sensor	1/3" B/W CCD
Picture Element	512(H) x 492(V) 251,000 Pixels
Scanning System	525 Lines, 60 Field/Sec
Scanning Frequency	15.743 Khz (H) x 59.9 Hz (V) EIA (NTSC) Standard
Resolution	380 TV Lines
Min. illumination	0.5 LUX, F1.6 3200K
Video Out	Composite 1V P-P 75 Ohm Unbalanced/ Internal Sync
	1/60-1/50000
Auto Shutter	Auto Iris Control
Lenses	1/3" Fixed, 780 Med. Wide-Angle Lens or Covert Pinhole, C-Mount (lens optional)
Power Consumption	DC9-15V. 100mA
Dimensions (mm)	40mmx45mmx25mm
WxHxD (inch)	151"x1.78"x1"
Weight	50g

Trimble

SVeeSix-CM3

GPS Module for Embedded OEM

Tracking & Communication Products

Gain An expanded feature set-low power consumption, fast warm start 12 volt antenna protection-at a lower integration cost

The SVeeSix-CM3 is Trimble's latest advance in GPS core module technology- Form-fir compatible with SVeeSix-CM2 application, the CM3 lowers integration costs while adding a wealth of features.

An antenna monitoring feature portects against cable shorts to ground or I2 volts, It also alerts the user should the antenna become shorted or disconnected. These unique capabilities make the SVeeSix-CM3 ideal for car navigation.

An optional second serial port allows for direct input of RTCM SC- 104 differential corrections. This feature dramatically lowers the cost of integrating differential.

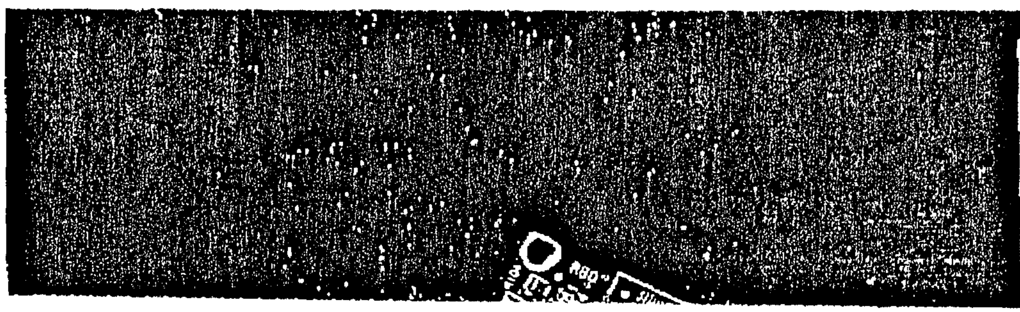
A real-time clock means faster acquisition. Users can begin operation without hooking up to a computer and downloading the time.

Optional passive antenna support adds flexibility. Andhe board's new design lowers power consumption.

A rugged and reliable six-channel receiver, the SVeeSix-CM3 provides position and velocity data anywhere on Earth, at any time of day, in any weather. It also provides accurate rime. A one-pulse-per-second signal is synch-ronizcd to UTC within a nominal accuracy of one microsecond-ideal for multi-site synchronization and time-distribution applications.

To help you evaluate and integrate the SVceSix-CM3, Trimble offers the System Designer's Starter Kit. It includes an RS-232 serial port adapter, a choice of binary, ASCII, or industry standard protocols, and source code for software interface programs.

More features, lower integration cost, and shorter integration time-three very good reasons For choosing the SVeeSix-CM3



Post-it™ brand fax transmittal memo 7671 | # of pages ▶ 3

To Todd Yoshimura	From Trimble
Co.	Co.
Dept.	Phone #
Fax # 413-268-5571	Fax # 703-904-1040

SVeeSix-CM3
GPS Module for Embedded OEM

Performance Specifications

General;	L1 frequency, CIA code (SPS), **6-channel,** continuous tracking receiver	
Update rate:	TSIP @ 2 Hz, NMEA & TAIP @ 1 Ha	
Accuracy:	Position:	25 m SEP without SA
	Velocity;	0.1 m/sec without SA
	Time:	I micro-second (nominal)
DGPS accuracy:	Position:	2 to 5 m (2 sigma)
	Velocity:	0.1 m/sec
	Time:	1 micro-second (nominal)
Acquisition (typical):	Cold start	2 to 5 minutes
	Warm start:	50 seconds
	Hot start:	30 seconds
Reacquisition:	<2 seconds	
Dynamics:	Velocity:	500 m/sec maximum
	Acceleration:	4g (39.2 m/sec^2)
	Jerk:	20 m/sec3

Environmental Specifications

Operating temp:	-10” to +60^{O}C (standard)	
	-40” to +85^{O}C (optional)	
Storage **temp:**	-55” to +100^{O}C	
Vibration:	0.008g2/Hz	5Hz to 20Hz
	0.05g2/Hz	20 Hz to 100 Hz
	-3dB/ocrave	100 Hz to 900 Hz
Operating humidity:	5% to 35% R-H. non-condensing @ +60^{O}C	
Altitude:	-400 m to + 18,000 m	

Technical Specifications

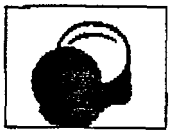
Prime power:	+5 volts DC (-3% to +5%)	
Power consumption (niminal):	SVeeSix-CM3: 230 ma, I - 15 watts with antenna: 240 ma, 1.20 watts	
Backup power:	+3 to +5 volts DC	
Backup consuption	1 micro-amp @+3 volts and +25^{O}C (nominal)	
Serial port / 1pps	CMOS TTL Icvcls	
Protocol options:	TSIP @ 9600 baud, g-Odd-1 NMEA 0183 v2.0@ 4800 baud, S-None-l TAIP @ 4800 baud, 8-None-l	
NMEA messages:	Standard:	GGA and VTG
	Optional:	Any combination of GGA, GLL, VIG, ZDA, GSA, GSV and RMC
Antenna power:	Short circuit protection Short circuit detection Short to +20 volt prorecrion Open dcrcction	

Physical Characteristics

Demensions:	3.25” Lx 1.83” W x 0 58” H (82.6 mm x 46.5 mm x 14.7 mm)
Weight	1.3 oz. (36.4 grams)
Conntors:	RF: SMB; I/O S-pin (2x4), 2 mm hca.

Upgrades and Accessories

Differential **GPS:**	Allows the module co decode and incorporate GPS corrections to improve position accuracy. Accepts RTCM SC-through secondary serial port or uses T and TAIP correction messages through primary porr.
GPS antenna and J Mount	Compact, active micropatch antenna a 5-meter cable and magnetic mount. 2.45” Diarnctcr x 0.45” High J Mount accessory for mounting on TTL or door Rangel.
Rooftop antenna:	Buller antenna with 75 feet of cable an SMB adapter.



Ordering Information

SVeeSix-CM3 modules:

26889-61	TSIP (binary) protocol
26889-62	KMEA (ASCIJ) protocol
26889-63	TAIP (ASCII) protocol

SVesSix-CM3 modules with DGPS option;

26890-61	TSIP (binary) protocol
26890-62	NMFA (ASCIl) protocol
26890-63	TAIP (ASCII) protocol

SVeeSix-CM3 with passive antenna support:

26891-61	TSIP (binary) protocol
26891-62	NMEA (ASCII) protocol
2689 I-63	TAJP (ASCII) protocol

GPS antenna:

26774-00	Magnetic mount antenna with 5-meter cable
2701840	JMount accessory kit

SVeeSix-CM3 Starter Kit:

21589-50	Includes SVeeSix-CM3 with DGPS, ma netic mount / antenna, TSIP NMEA and TAIP firmware, software toolkits for TSIP and TAIP interface cable, and manual.

Now: Other configurations are available. Consult your local Trimble representative for details.

Specifications are subject to change without notice

AUTOGYRO®

Navigator

ANDREW®

A location of the position of vehicles on roads and highways is an essential aspect of the development of Intelligent Transportation Systems (ITS). Although the Global Positioning System (GPS) provides worldwide geographic location information, the accuracy is limited by the imposition of random variations called Selective Availability (S/A). Location and navigation systems that demand continuous coverage cannot depend solely on GPS, as the radio transmissions are blocked by buildings, heavy foliage, and rugged terrain. Filling in these gaps, and smoothing the GPS data itself is most economically done with dead reckoning.

Dead reckoning systems navigate on the earth by determining the azimuth of the vehicle and the distance traveled. An economical method of performing this task is with an inertial measurement of the angular rotation performed by a gyroscope combined with distance measurement performed by the vehicle odometer. The GPS data is used to bound and correct the inaccuracies which accumulate with time. Andrew has developed the AUTOGYRO@ Navigator to perform this function in an accurate and economic manner.

Angular rotation data are integrated to determine the change in vehicle azimuth and the number of odometer pulses totaled for the interval and combined into a serial digital data output. Fabricated from Andrew ECore polarization maintaining optical fiber and operating from unconditioned vehicle power, the AUTOGYRO@ Navigator is the ideal dead reckoning sensor. An analog output version is also available.

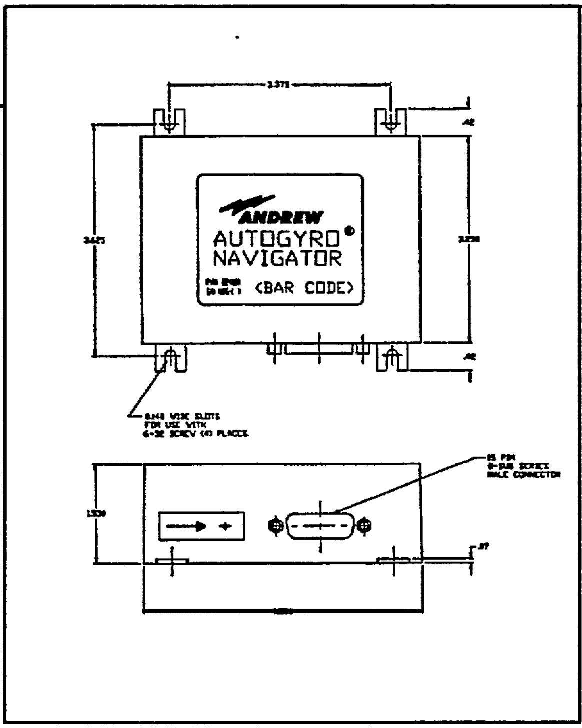
Product Specifications

Characteristic	Performance
Rotation Kate, deg/sec	" 100
Scale Factor Linearity, percent rms constant temp full temp	 < 0.5 < 1
Scale factor vs Temperature, percent	< 1
Angle Ranfom Walk, Deg/hr/Hz Deg/hr	 20 0.33
Instantaneous Bandwidth, Hz	100
Bias Drift, deg/sec	0.005 (fixed temp) 0.025 (repeatability)
Temperature range, deg C Operating Storage	 -40 to +75 -50 to +85
Warm-up time	1 sec
Power Supply Voltage, VDC	+ 9 to +18, transient and reverse voltage protected
Output Data Analog Digital	 +2.5 VDC (zero rotation) " 2V, into 1 OK Ohm, 20 mv/deg/sec scale factor 16 bits, serial, RS-232, 9600 BPS, IO values per second
Power Consumption, watts Analog Digital	 < 2 < 3
Physical Consumption, watts Analog Digital	 < 2 < 3
Physical Dimensions In mm	 4.5 X 3.5 X 1.6 115 X 90 X 41
Weight lbs kg	 0.55 0.25

Point your Land Navigation System in the right direction . . .

Interfaces

Mechanical



Electrical

Pin No.	Analog Gyro	Digital Gyro RS232 (RS422)
1	+12V Power	+12V Power
2	Power Common	Power Common
3	Spare	Spare
4	Spare	Spare
5	-Spare	Spare
6	VSS Out	Spare
7	-- Reverse Out	Txl
8	Fault	Spare (Txl -)
9	Temp	Spare
IO	Temp Common	Spare
I I	Rate Out	Spare
12	Rate Ref (+2.5 VDC)	Spare
13	VSS In	VSS In
14	-Reverse In	Reverse In
15	Signal Common	Signal Common

	Part Number
Analog Output	225210-1
Digital Output (RS232)	225140-I
‘Digital Output (RS422)	225 140-2

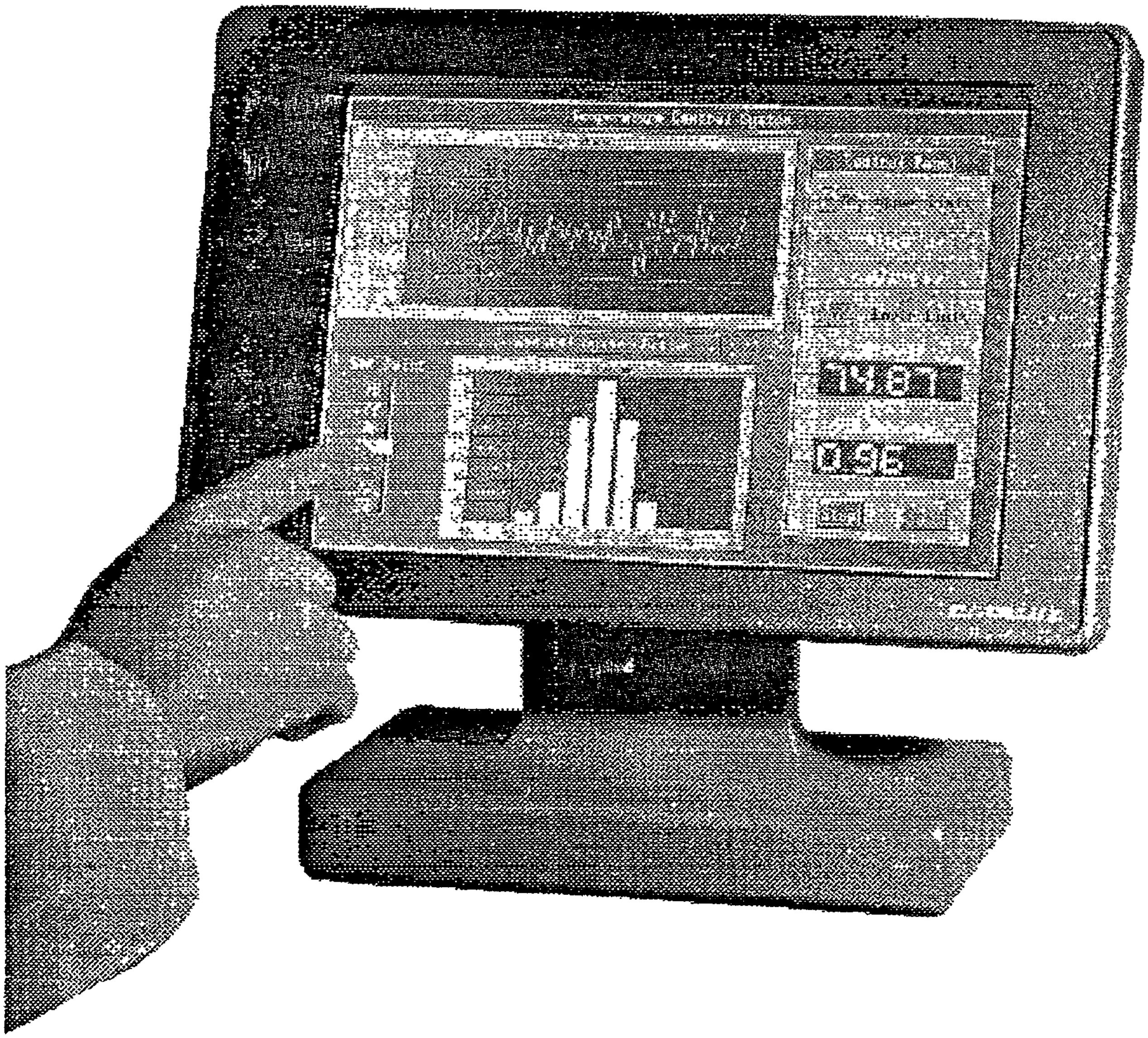
For further information or to place an order, call the Customer Support Center (800) 255-1479 Ext. 95

Outside the U.S. call (708) 873-2307 • Ask for the Customer Support Gnter • FAX (708) 349-5444

10500 W. 153rd St., Orland Park, IL U.S.A. 60462

DATALUX

10.4" LCD & TOUCH MONITORS



DATALUX introduces its new line of 10.4" Stand alone LCD Monitors with quality construction and innovative features expected from the industry leader.

All monitors are sealed and may be equipped with optional touch screen. Eivil shielding is standard and the Dual Scan color panels are 50% brighter than a notebook display. Eight separate mounting options are available using a unique friction tilting mechanism that maintains stability in any position while the touch screen is berng used.

These monitors require no external power supply and may be driven by any PC using a video controller supplied by DATALUX or directly (without the card) from a Databrick corn puter. The monitors are operable at up to 50 feet from the CPU with no loss in picture quality.

..-25-96 MON 9:37 TRI STATE VIDEO P.01

ATTN: JIM KOCHER From: CHUCK MILLER

ORDER NO. VSD9110 M213
D1

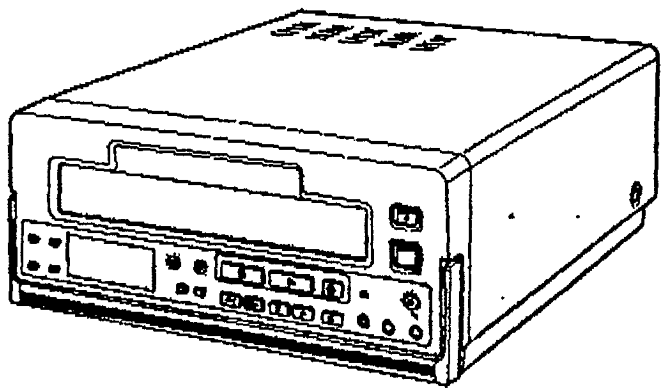
Service Manual

Video Cassette Recorder

Panasonic S-VHS Hi-Fi

AG-5700-P

Sec. 1	*Operating Instructions*
Sec. 2	*Disassembly Procedures, Maintenance, Mechanical Adjustment & Electrical Adjustment*
Sec. 3	*Block Diagrams*
Sec. 4	*Schematic Diagrams & Circuit Board Diagrams*
Sec. 5	*Exploded Views & Replacement Parts Lists*



SPECIFICATIONS

ITEM	SPECIFICATION
Power	Source: AC 120 V, 50~60 Hz Consumption: Approx. 26 W
Television Format	NTSC System (525 lines, 60 fields)
Tape Speed	33.35 mm/s (2H), 11.12 mm/s (6H)
Tape Format	VHS tape, S-VHS tape
Recording Playback Time	120 min. with NV-T120 (2H)
FF/REW Time	Approx. 3 min. with NV-T120
Video	Head: 2 rotary heads, helical scanning system
	Luminance: FM azimuth recording
	Colour signal: Comverted subcarrier phase shift recording
	Input Level. VIDEO IN (BNC): 1.0 Vp-p 75Ω unbalanced S-VIDEO (4P), Y: 1.0 Vp-p, 75Ω unbalanced C: 0.286 Vp-p, 75Ω unbalanced (burst level)
	Output level: VIDEO IN (BNC); 1.0 Vp-p 75Ω unbalanced S-VIDEO (4P); Y: 1.0 Vp-p, 75Ω unbalanced C; 0.286 Vp-p, 75Ω unbalanced (burst level)
	Signal-to-Noise Ratio: 45 dB (B/W, colour)
	Horizontal Resolution: VHS; 240 lines (B/W, color) S-VHS; 400 lines (b/w, color)

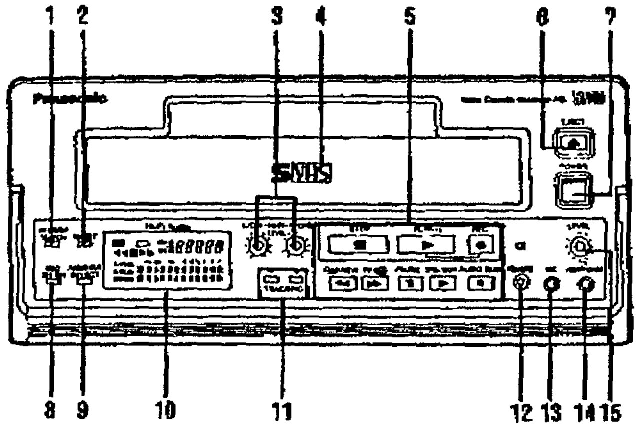
ITEM	SPECIFICATION
Audio	Head. Normal Audio/Control; 1 stationary head Hi-Fi Audio, 2 rotary heads Erase; 1 full track erase 1 Audio track erase
	Track: Hi-Fi; 2 tracks Normal, 1 track
	Input Level. AUDIO IN (PHONO): −8 dBv, 47 kΩ unbalanced MIC IN (Mini Jack): − 60 dB, 600Ω
	Output Level: AUDIO OUTPUT (PHONO); 8 dBv, 1 kΩ unbalanced HEADPHONE (M3); 8Ω
	Frequency response: Normal, 50 Hz~10 kHz (2H) 50 Hz~3 kHz (6H) Hi-Fi, 20 Hz~20 kHz
	Hi-Fi Dynamic Range. 90 dB
	Signal-to-Noise Ratio: 45 dB (Normal)
Remote	Mini Jack (FRONT), RS-232C (REAR)
Operating Condition	Temperature: 41°F~104°F (5°C~40°C) Humidity: 35%~80%
Dimensions	10-5/8" (W)×4-11/16" (H)×13-5/16" (D) 270 mm (W)×120 mm (H)×340 mm (D)
Weight	Approx. 12.3 lbs 5.6 kg
Standard Accessory	S-VIDEO Cable (4P)
Optional Accessory	Remote Controller, AG-A11

Specifications are subject to change without notice.
Weight and dimensions shown are approximate.

1-on
2-on
> AG-A570

Controls

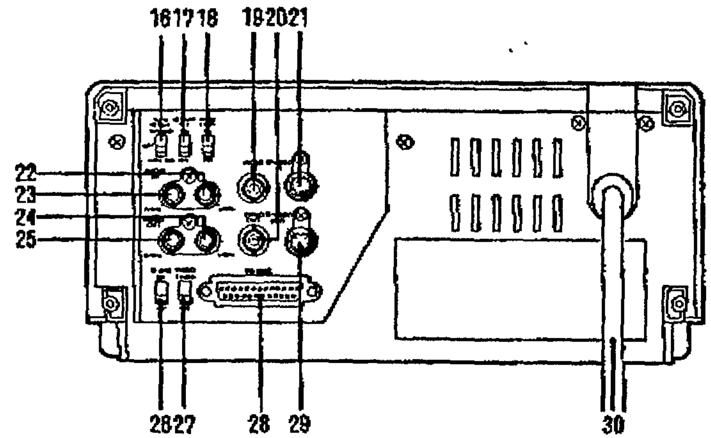
Front



No.	Name
1	Memory/Search Button
2	Reset Button
3	Hi-Fi Audio CH1/CH2 Level Controls
4	Cassette Holder
5	Operation Buttons STOP, PLAY, REC, REW, FF, PAUSE, STILL/SLOW, AUDIO DUB
6	Eject Button
7	Power Switch

No.	Name
8	Recording Mode Selector
9	Audio Monitor Output Selector
10	Counter/Audio Level Meters
11	Tracking Buttons
12	Remote Jack (Mini-Jack)
13	Microphone Jack
14	Headphone Jack (Mini-Jack)
15	Headphone Level Control

Rear



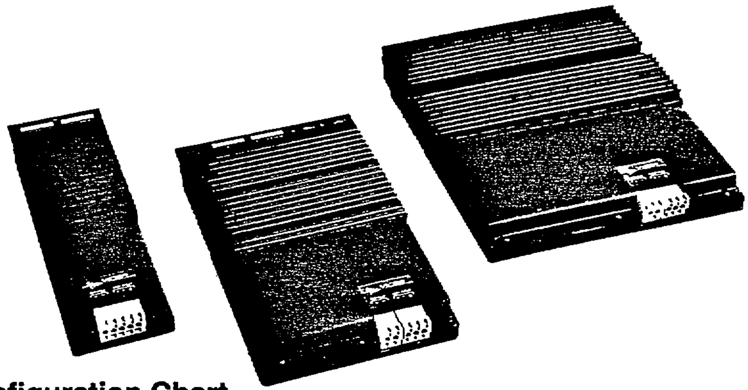
No.	Name
16	Auto Repeat Switch
17	Sensor Recording Switch
18	Mode Lock Switch
19	VIDEO IN Connector (BNC)
20	VIDEO OUT Connector (BNC)
21	S-VIDEO IN Connector (BNC)
22	Audio L/CH1 IN Connector (PHONO)
23	Audio R/CH2 IN Connector (PHONO)

No.	Name
24	Audio L/CH1 OUT Connector (PHONO)
25	Audio R/CH2 OUT Connector (PHONO)
26	S-VHS Selector
27	Video Selector
28	RS-232C Remote Control Connector
29	S-VIDEO OUT Connector
30	Power Cord

VICOR

ComPAC™

DC-DC Switchers 50 to 600 Watts 1-3 Outputs



Features:

- Inputs: 24, 48 and 300 VDC
- Any Output: 1 to 95 VDC
- High Surge Withstand: Bellcore, British Telecom BTR 2511, IEC-801-5
- EMI/RFI Specifications: Bellcore TR-TSY-000513, British Telecom BTR 2511 FCC/VDE Level "A"
- UL, CSA, TÜV, VDE
- 80-90% Efficiency
- Up to 10 Watts/Cubic Inch
- Reverse Polarity Protected
- Master Disable
- Overvoltage Shutdown
- "1 Up": 50-200 Watts (single) 8.6"L x 2.5"W x 0.99"H
- "2 Up": 100-400 Watts (single, dual) 8.6"L x 4.9"W x 0.99"H
- "3 Up": 150-600 Watts (single, dual, triple) 8.6"L x 7.3"W x 0.99"H

Product Highlights:

ComPAC meets Bellcore, British Telecom and IEC specifications for transient protection; Bellcore, British Telecom and FCC/VDE specifications for EMI/RFI; and benefits from the proven field performance, high efficiency and inherently high reliability of our VI-200 component-level power converters. With input voltage ranges optimized for industrial and telecommunication applications, ComPAC provides extended input overvoltage capability, input reverse polarity protection, undervoltage lockout and master disable. In a package just .99" in height, ComPAC delivers up to 600 watts from one, two or three outputs of 1 to 95 VDC.

ComPAC Configuration Chart

Single Outputs:	VI-LC ■■ - ■□	50-200W	8.6"L x 2.5"W x 0.99"H
	VI-MC ■■ - ■□	100-400W	8.6"L x 4.9"W x 0.99"H
	VI-NC ■■ - ■■	300-600W	8.6"L x 7.3"W x 0.99"H
Dual Outputs:	VI-PC ■■■ - ■□□	100-400W	8.6"L x 4.9"W x 0.99"H
	VI-QC ■■■ - ■□□	150-600W	8.6"L x 7.3"W x 0.99"H
Triple Outputs:	VI-RC ■■■■ - ■□□□	150-600W	8.6"L x 7.3"W x 0.99"H

Input Voltage

Nominal	Range
1 = 24V	21 - 32V(1)
W = 24V	18 - 36V(1)
3 = 48V	42 - 60V(2)
N = 48V	36 - 76V(2)
6 = 300V	200 - 400V(2)

Output Voltage

Z = 2V	2 = 15V
Y = 3.3V	3 = 24V
0 = 5V	L = 28V
M = 10V	4 = 48V
1 = 12V	

1 to 95V, consult factory.

Product Grade

E =	-10°C to +85°C
C =	-25°C to +85°C
I =	-40°C to +85°C
M =	-55°C to +85°C

Output Power/Current

	$V_{OUT} \geq 5V$	$V_{OUT} < 5V$
Y =	50W	10A
X =	75W	15A
W =	100W	20A
V =	150W	30A
U =	200W	40A

Output Power/Current

	$V_{OUT} \geq 5V$	$V_{OUT} < 5V$
W =	100W	20A
V =	150W	30A
U =	200W	40A
S =	300W	60A
Q =	400W	80A

Output Power/Current

	$V_{OUT} \geq 5V$	$V_{OUT} < 5V$
S =	300W	60A
P =	450W	90A
M =	600W	120A

Max. Output For	5V Outputs	> 5V Outputs	< 5V Outputs
(1)	150W	150W	30A
(2)	200W	200W	40A

Long Term Safe Operating Area Curves

(1% duty cycle max., Z_S = .5Ω, for short duration transient capability refer to specifications)